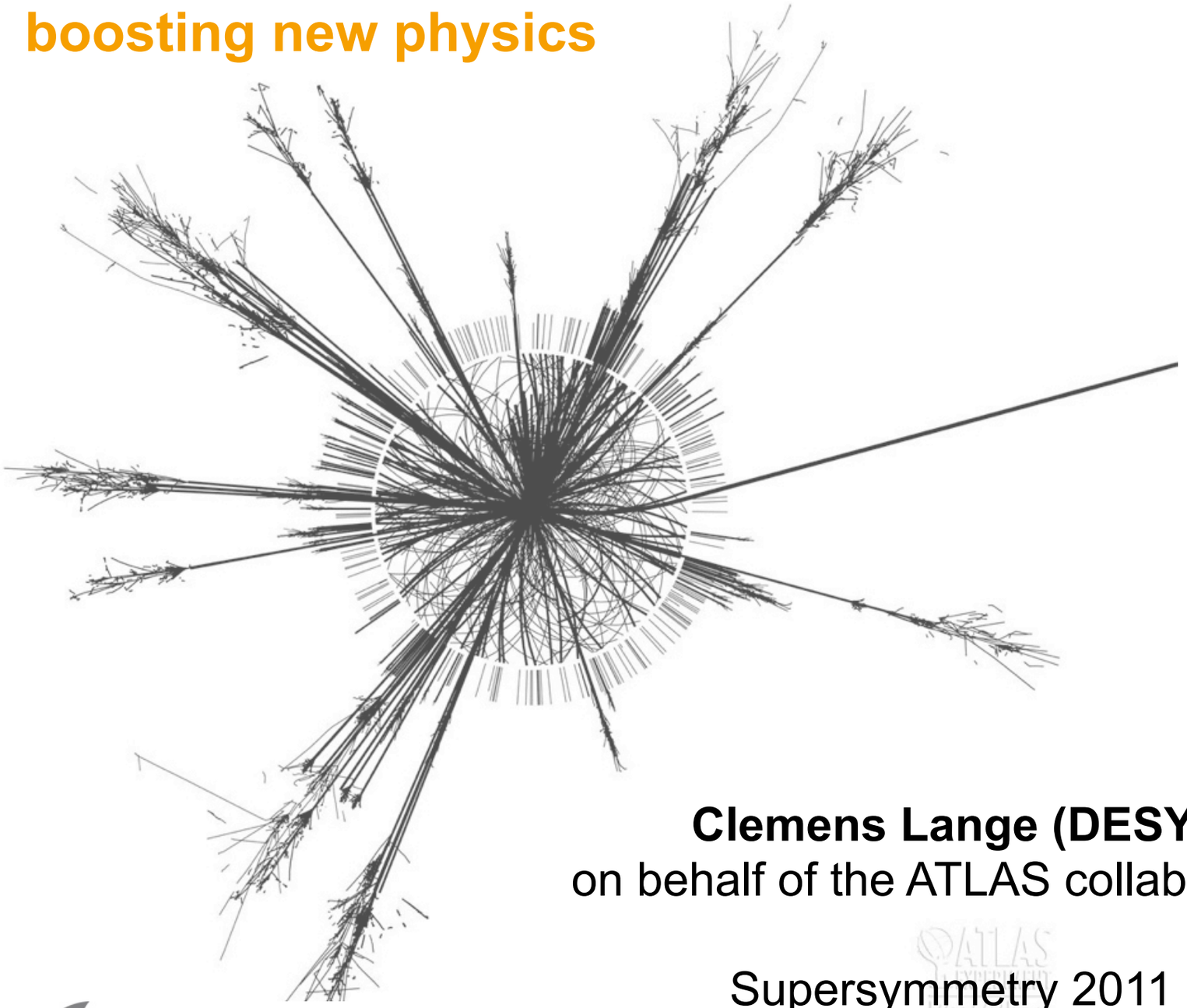
Search for new physics in top and top-like final states with ATLAS.

boosting new physics



contents

semi-leptonic channel:
- ttbar + missing E_T
- resonances
- FCNC and anomalous couplings

dileptonic channel:
- fourth generation quarks
- resonances

Clemens Lange (DESY)
on behalf of the ATLAS collaboration

Supersymmetry 2011
Fermilab/University of Chicago

31st August 2011

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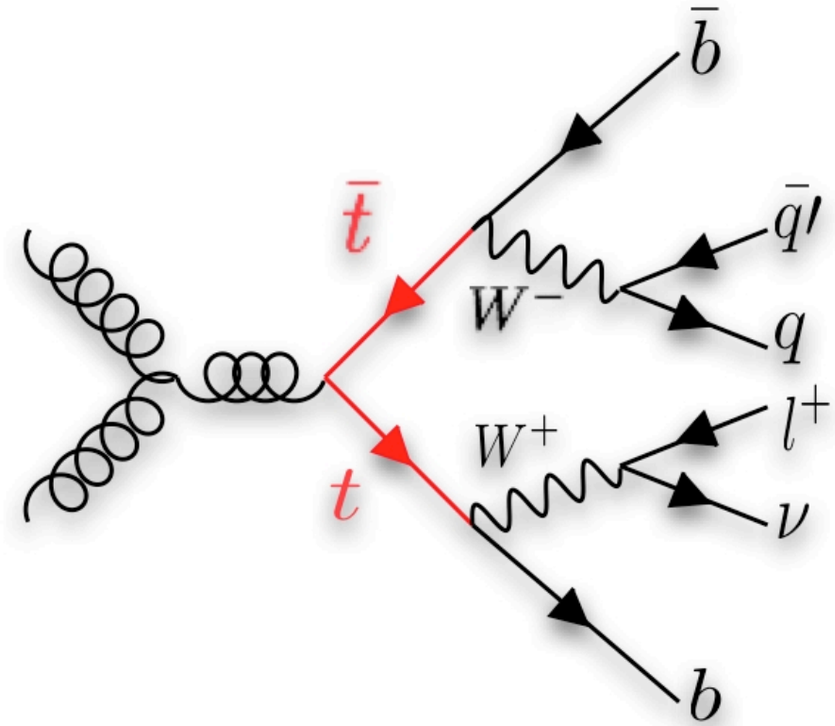
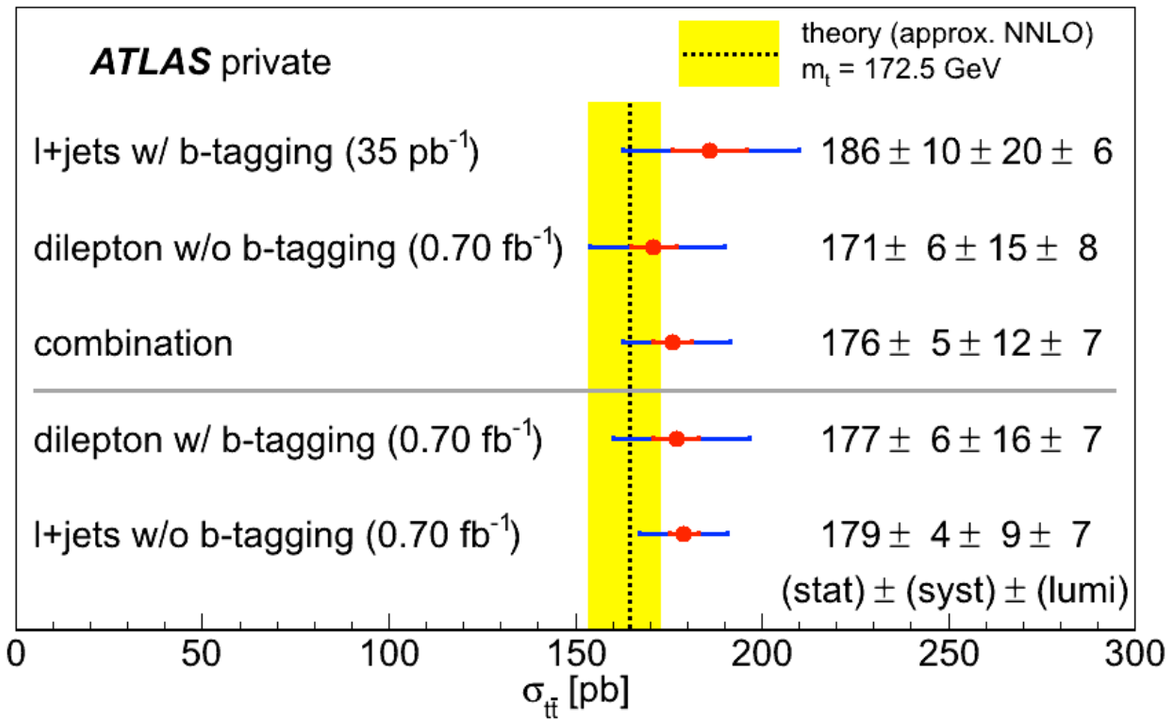
top quark physics

ATLAS-CONF-2011-121
ATLAS-CONF-2011-108

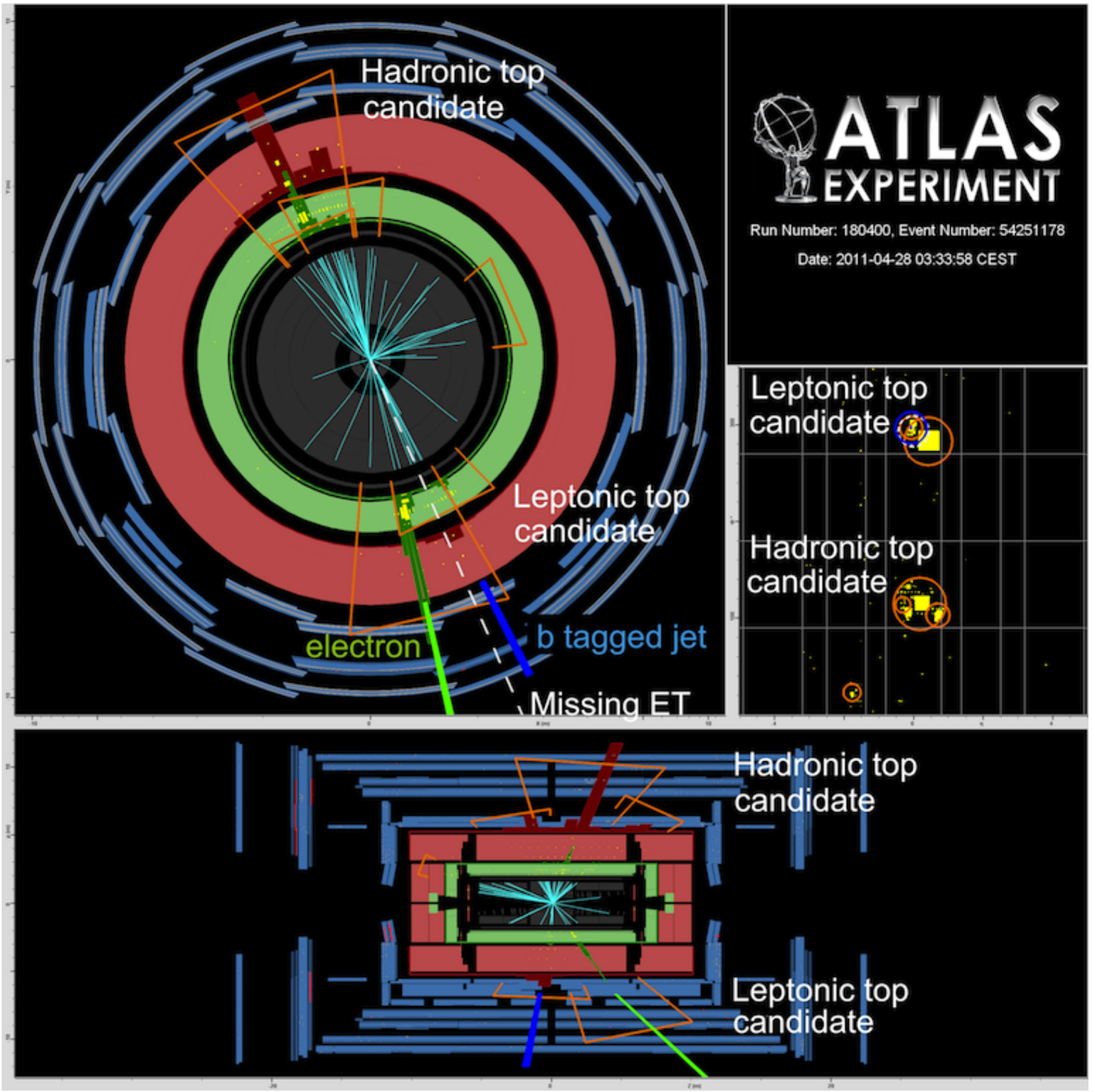
- heaviest fundamental particle known today
- opens up field of high-p_T physics
- already very well understood at ATLAS
  - most precise single cross-section measurement
  - several properties measured
- exceptional status for new physics, especially if new physics couples to the mass
- Tevatron: ~7800 top pairs per 1 fb^{-1}
- LHC: ~165000 per 1 fb^{-1}





single lepton signal signature

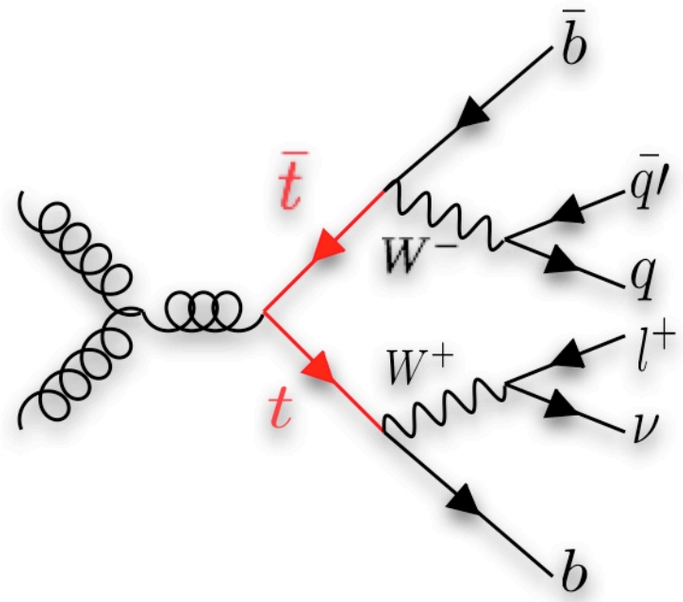
ATLAS-CONF-2011-087



- 1 lepton (electron or muon)
- at least 4 jets
- one of them b-tagged
  - secondary vertex or track/jet compatibility with primary vertex

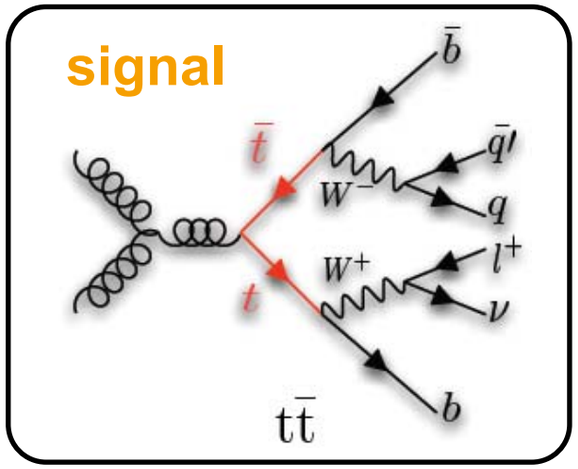
at high m_{tt}:

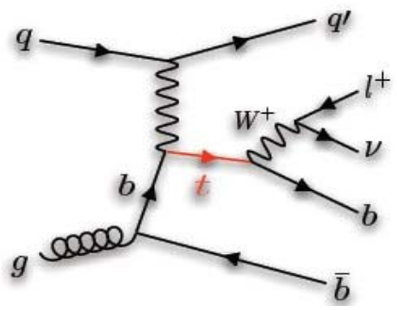
- can one still resolve all objects in final state?



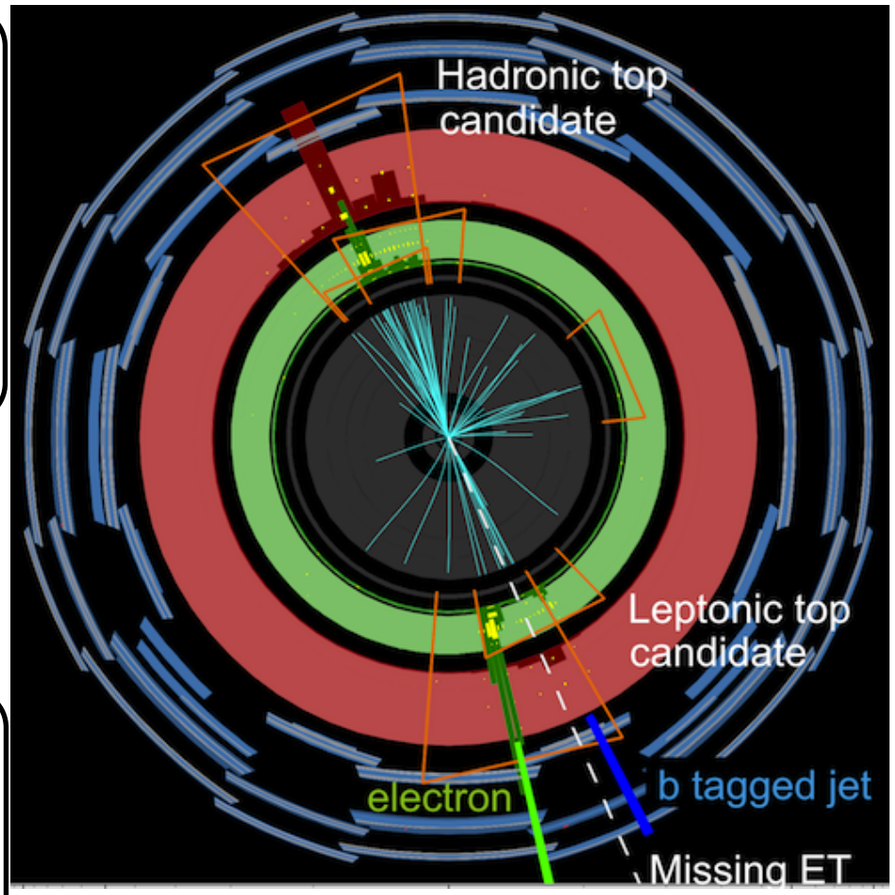
background processes

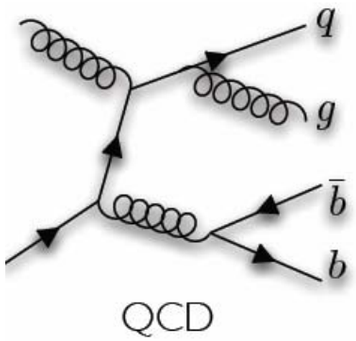
- several processes have similar final states
- object identification is not perfect



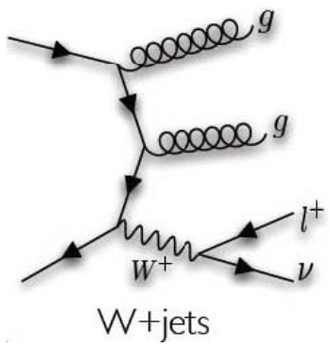


single top:
- real top decay
- additional jets and b-jets



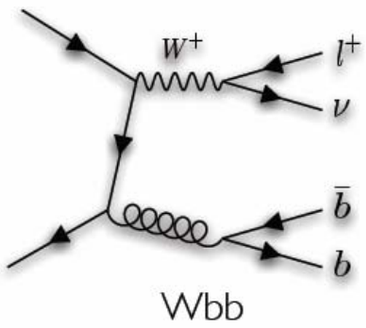


QCD:
- jets and b-jets
- fake lepton via mis-identified jet



W+jets
- leptonic W decay
- additional jets

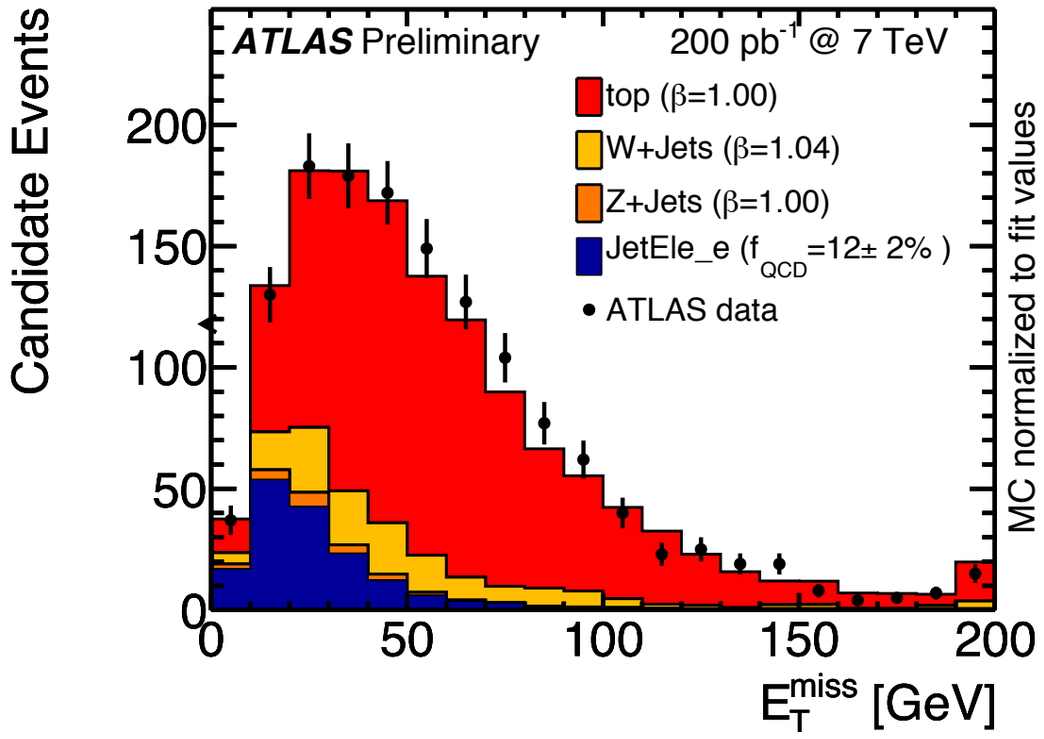
they all look like this

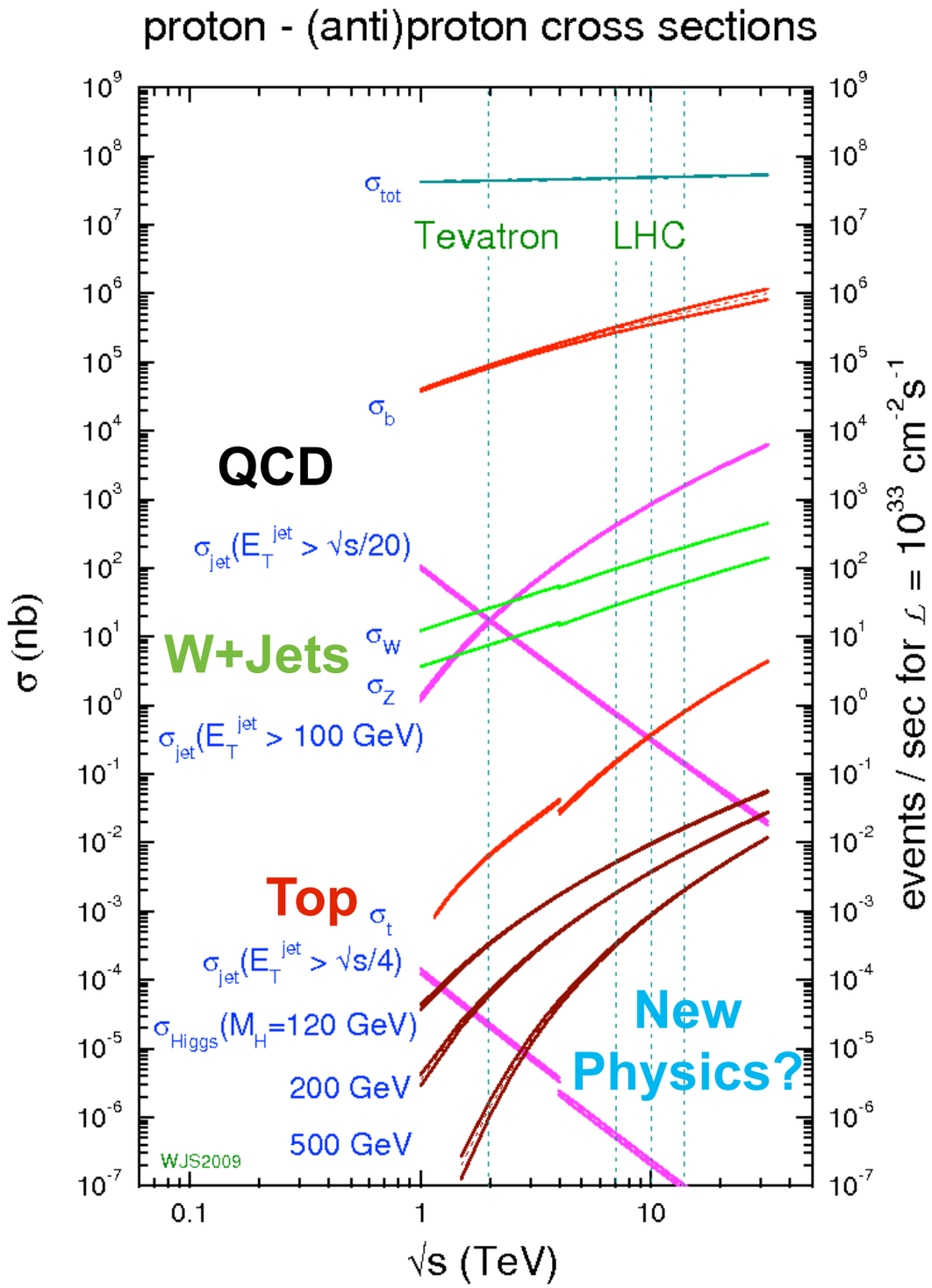


W+heavy flavour+jets:
- leptonic W decay
- additional jets and b-jets

estimation of background

- ttbar irreducible
- W+jets normalization from data (reduced requiring b-tag)
- W+heavy flavour+jets fraction estimated from data
- QCD not well modelled in MC, obtain model from data and fit fraction using missing transverse energy distribution

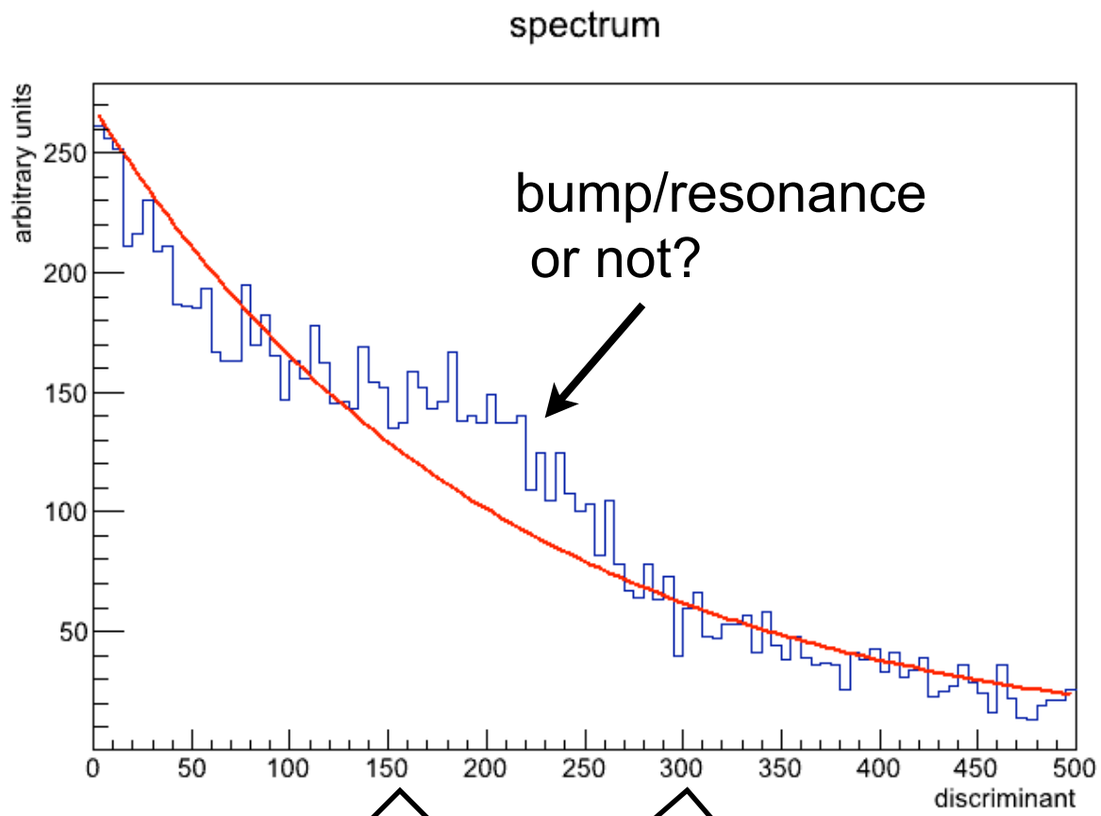




how to search for new physics with top

ATLAS-CONF-2011-087

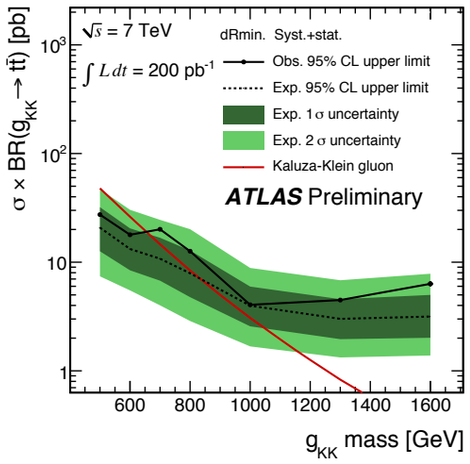
- new physics will lie in regions that could not be reached energetically before
- first establish top signal
- need to understand top production and properties
- look at tails of distributions
- search for bumps in spectra
- look at substructure of jets (boosted objects)
- if no excess found, set exclusion limits



significant

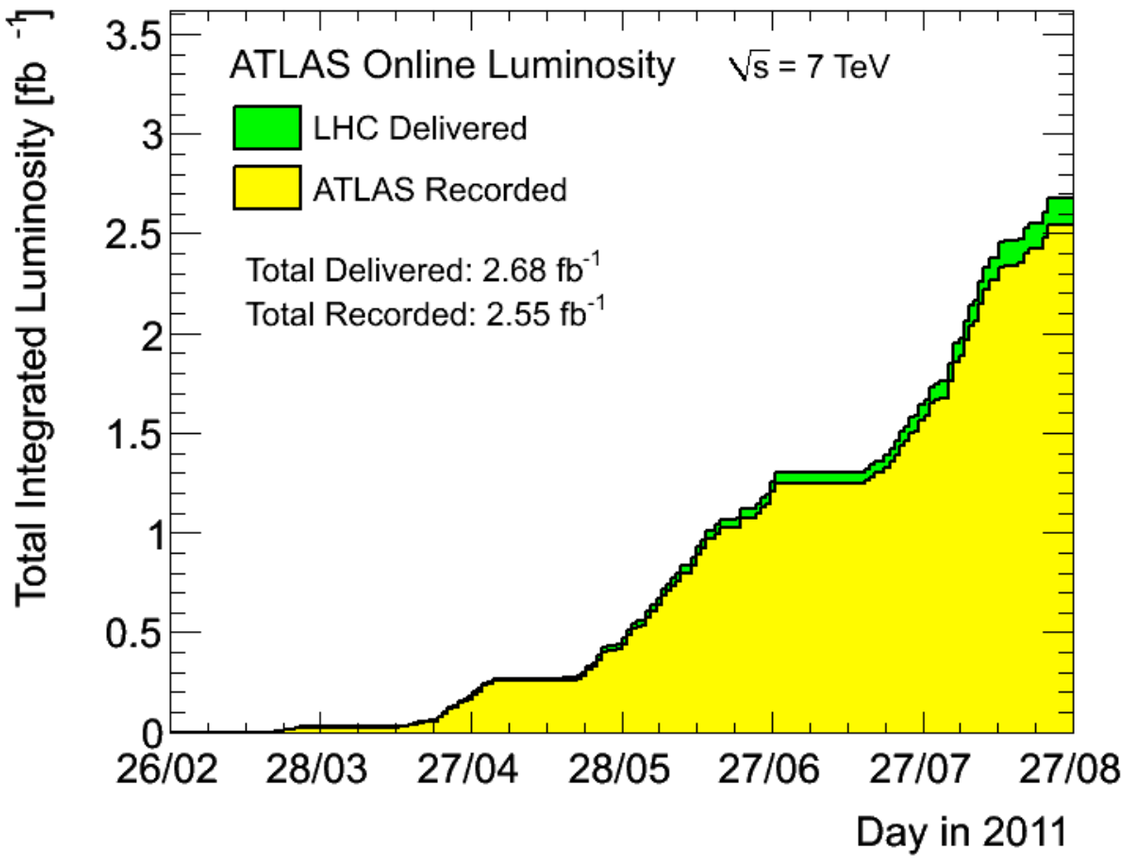
not significant

new physics!
- **measure cross-section**
- **measure properties**
- **...**



dataset

- LHC: outstanding performance in 2011 at 7 TeV
- ATLAS has very high data-taking efficiency
- This talk contains results based on luminosities of 35 pb^{-1} to 1.04 fb^{-1}

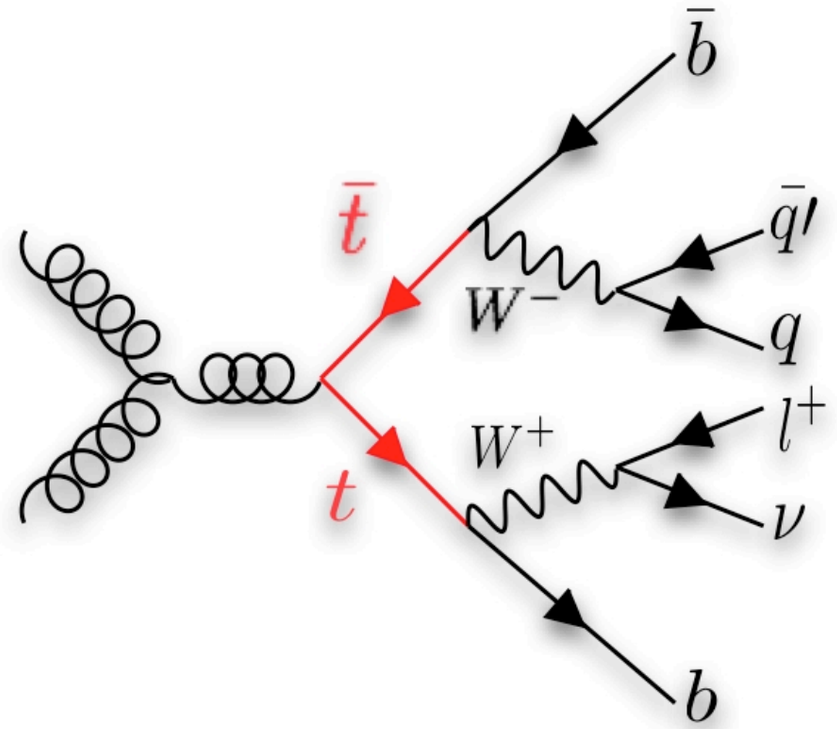


Inner Tracking Detectors			Calorimeters				Muon Detectors				Magnets	
Pixel	SCT	TRT	LAr EM	LAr HAD	LAr FWD	Tile	MDT	RPC	CSC	TGC	Solenoid	Toroid
99.9	99.9	100	90.0	91.3	94.8	98.2	99.5	99.7	99.9	99.6	99.6	99.4

Luminosity weighted relative detector uptime and good quality data delivery during 2011 stable beams in pp collisions at √s=7 TeV between March 13th and August 13th (in %). The inefficiencies in the LAr calorimeter will largely be recovered in the future.

semi-leptonic signature

exactly one lepton in final state



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top pairs plus missing transverse energy

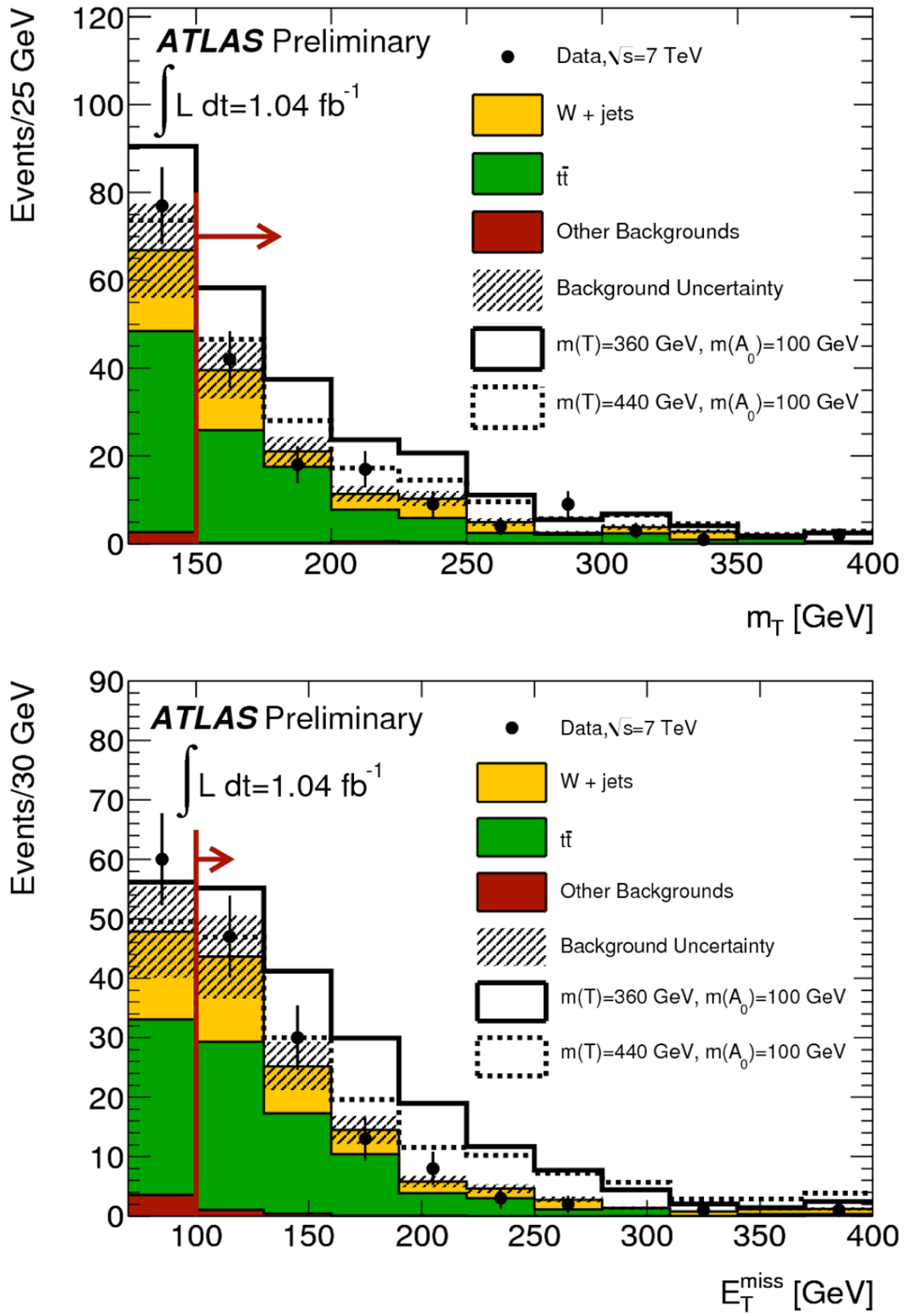
ATLAS-CONF-2011-036
+ updates

- data excess at high missing E_T might hint at new heavy particles:

  TT → ttA_0A_0 (A_0 additional heavy particle)

  - e.g. dark matter, stop quark pair production (arXiv:hep-ph/0105239, JHEP **0309**, 051 (2003))

- requires good understanding of MET
- good data-MC agreement



top pairs plus missing transverse energy

ATLAS-CONF-2011-036
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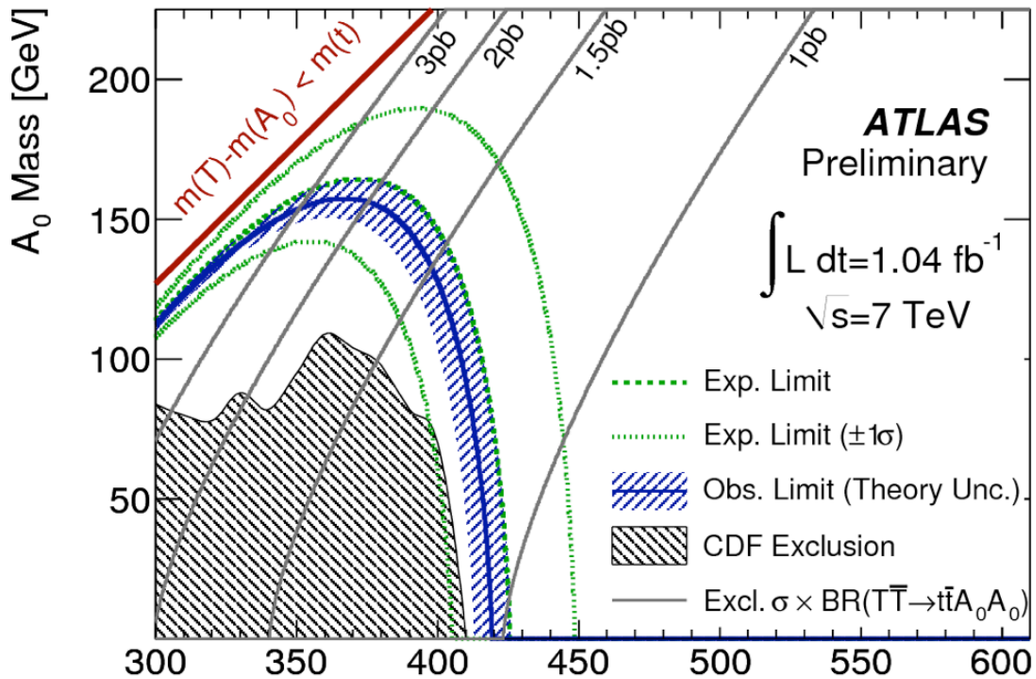
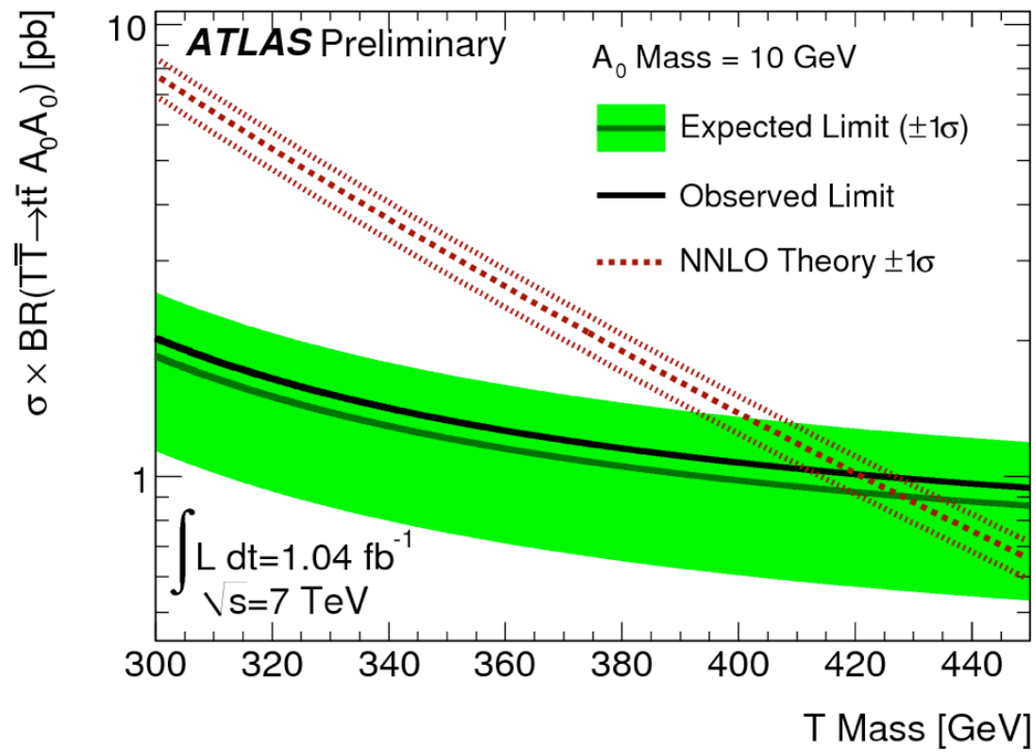
  TT → ttA_0A_0 (A_0 additional heavy particle)

  - e.g. dark matter, stop quark pair production (arXiv:hep-ph/0105239, JHEP **0309**, 051 (2003))

- requires good understanding of MET
- good data-MC agreement
- no heavy particle signal found
- exclusion of quark like heavy particles decaying to top plus neutral particle (arXiv:0909.3555):
  - 370 GeV T decaying into top and 140 GeV A_0
  - 420 GeV T decaying into top and 10 GeV A_0

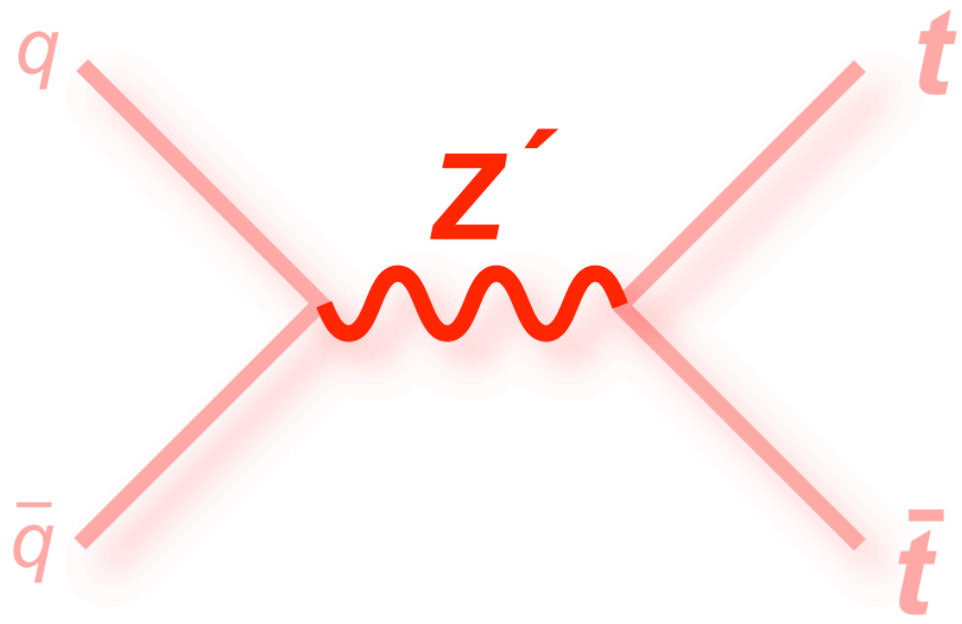




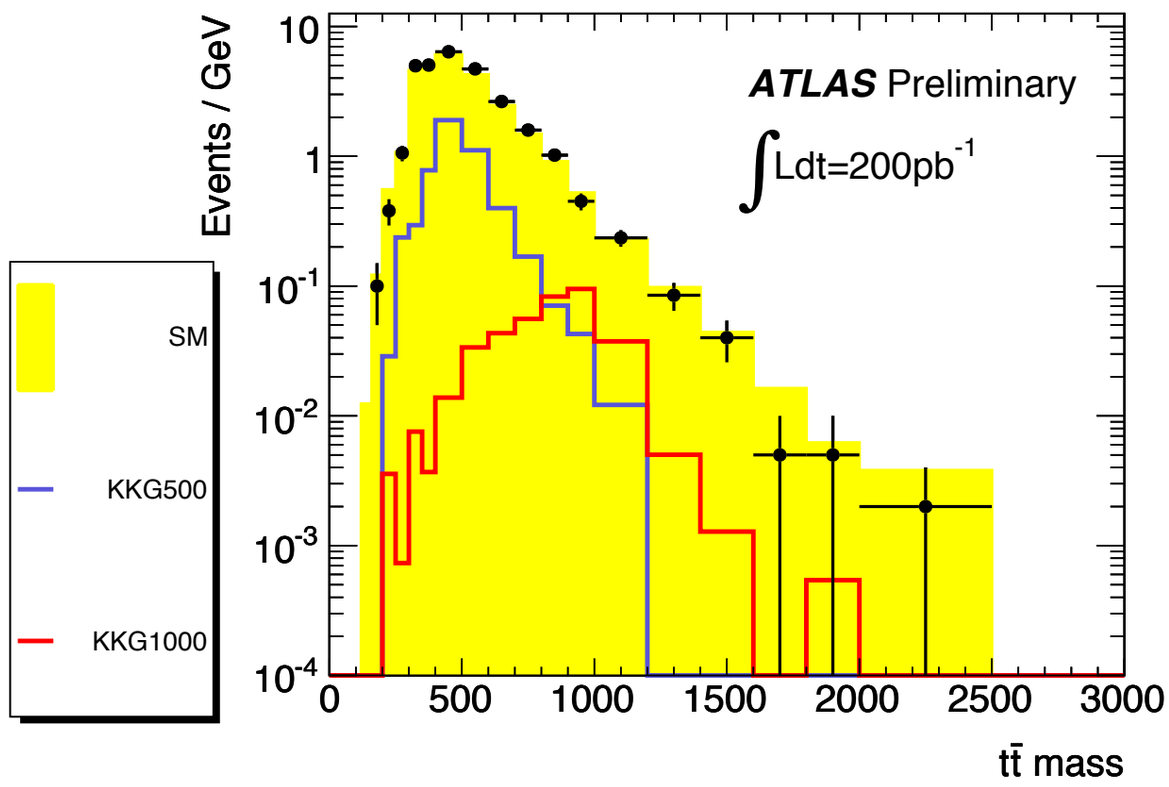
top resonances: mass reconstruction

ATLAS-CONF-2011-070
ATLAS-CONF-2011-087

- search for Z‘/Kaluza Klein gluons
- use simple and robust mass reconstruction scheme
- reconstruct full final state, i.e. ttbar system

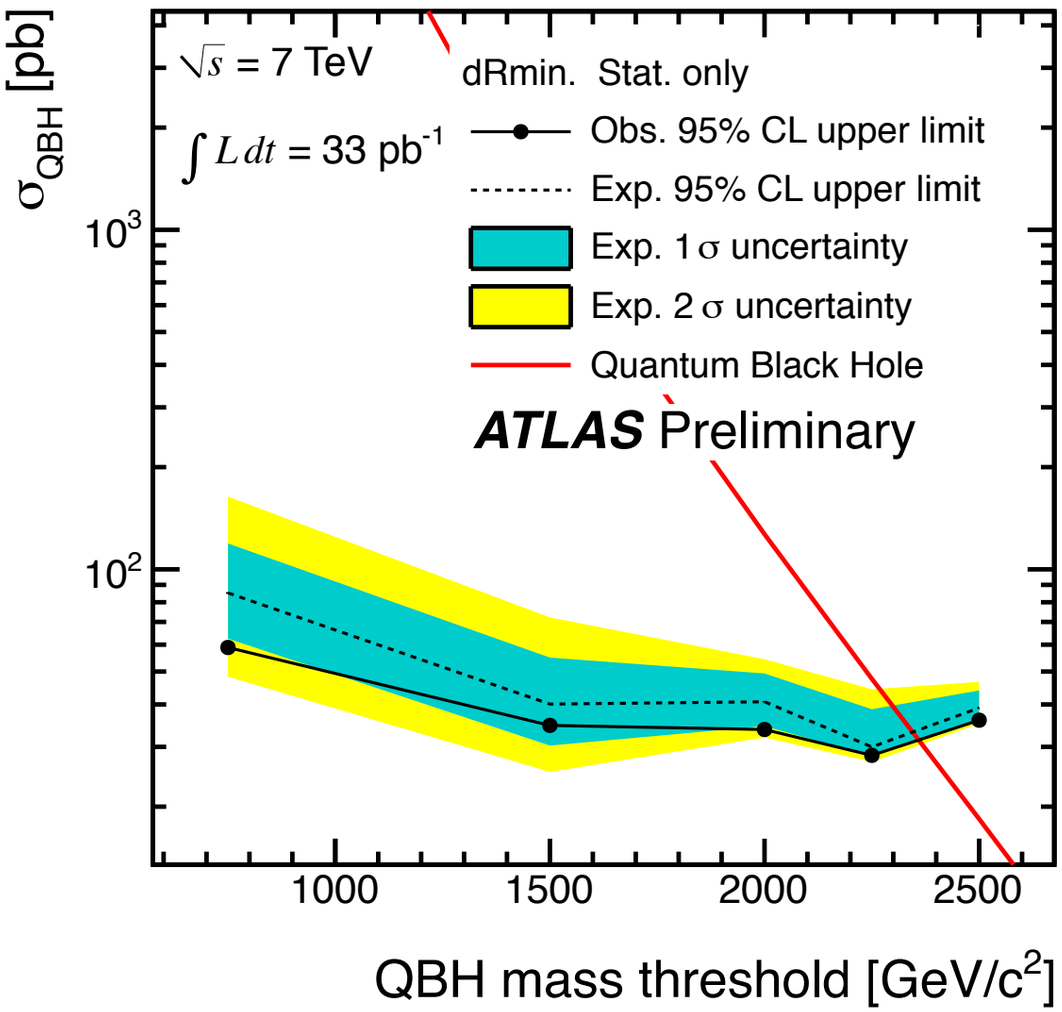


- using four leading jets for m_{tt} leads to a long tail in resolution due to initial state radiation (ISR)
- better: exclude jets that are clearly separated from other objects in the event (ISR candidates)



limits for black holes

ATLAS-CONF-2011-070

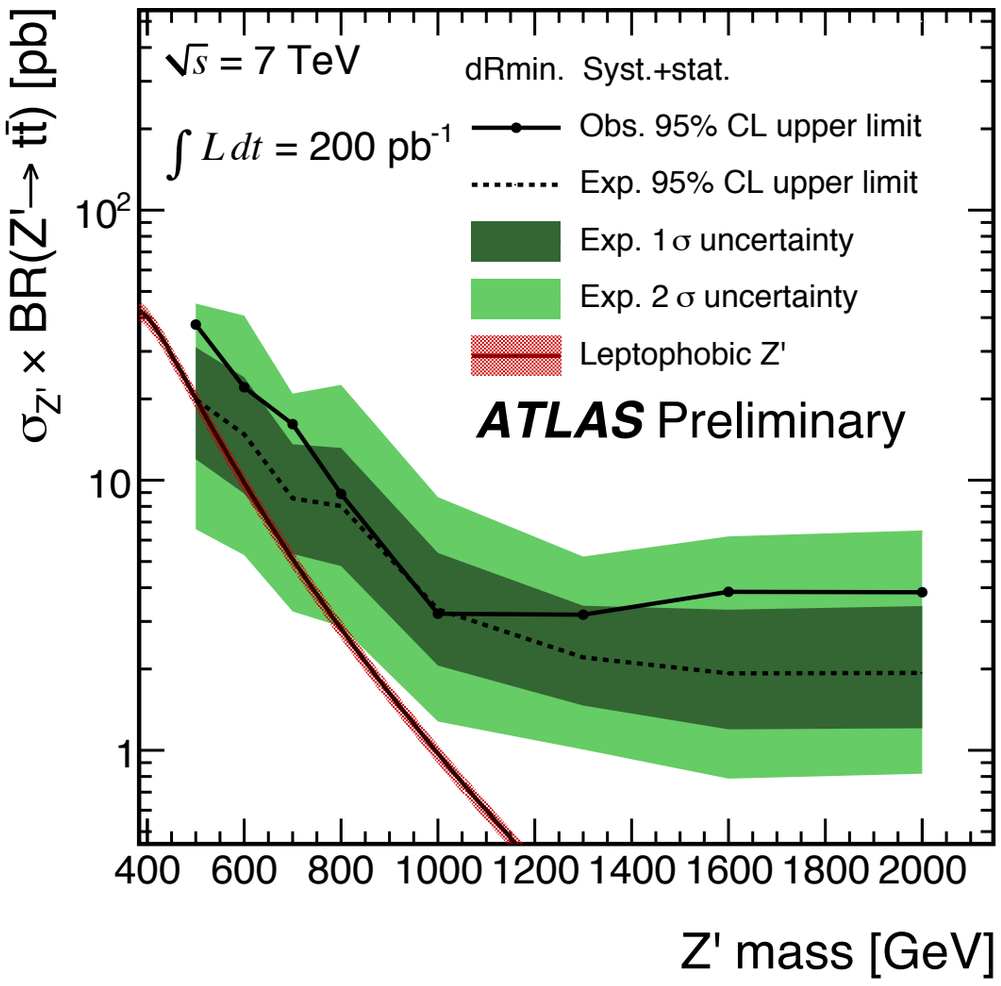


- black holes decaying via strong gravitational scattering
  - JHEP 0805 (2008) 003
  - Phys. Lett. B594 (2004) 363–367
- 24-38% branching ratio (750-2500 GeV black hole threshold mass) of t+X and low parton multiplicity
- look for excess of tops at high m_{tt}
- exclude quantum black hole mass thresholds below 2.35 TeV

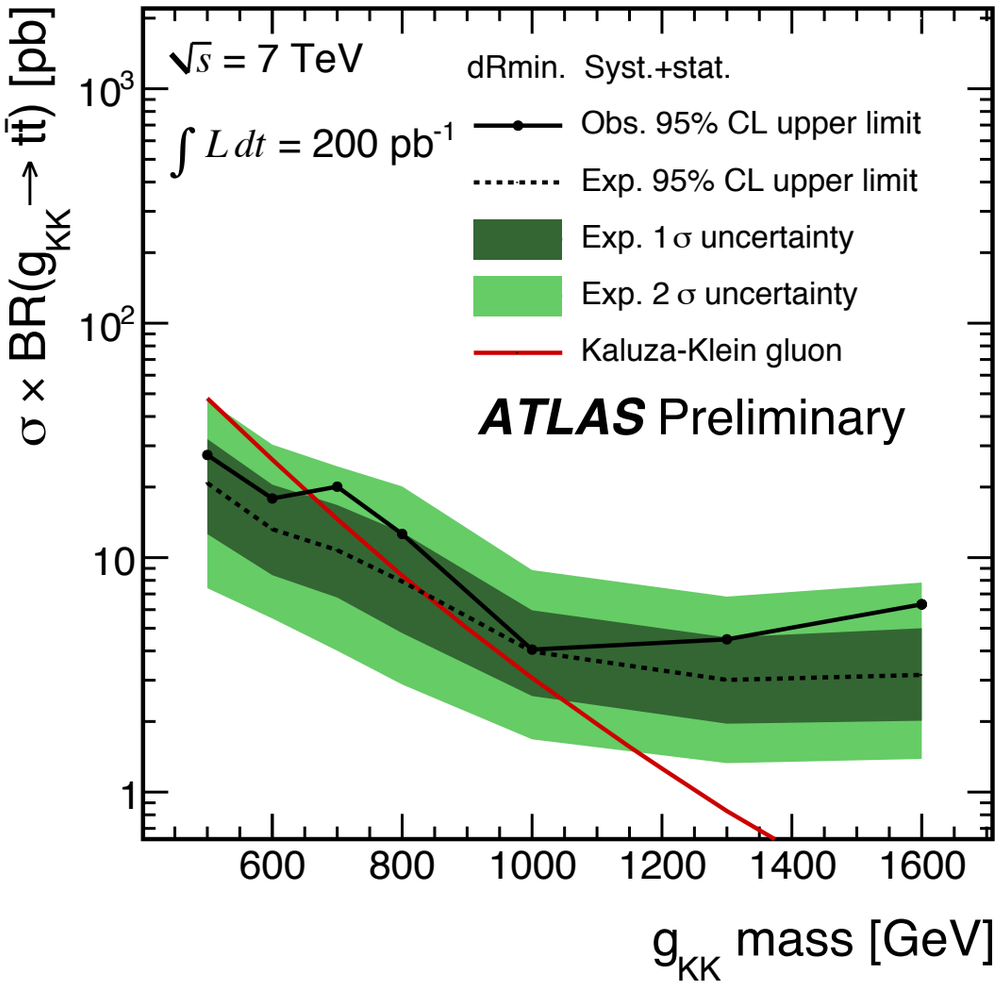
limits for resonances

ATLAS-CONF-2011-087

narrow Z‘ produced weakly



wider Kaluza Klein gluons produced strongly



Leptophobic Top-Color:

- arXiv:hep-ph/9911288
- No exclusion up to now (200 pb^{-1})
- Tevatron exclude m_{tt}~900 GeV with 3-5 fb^{-1}

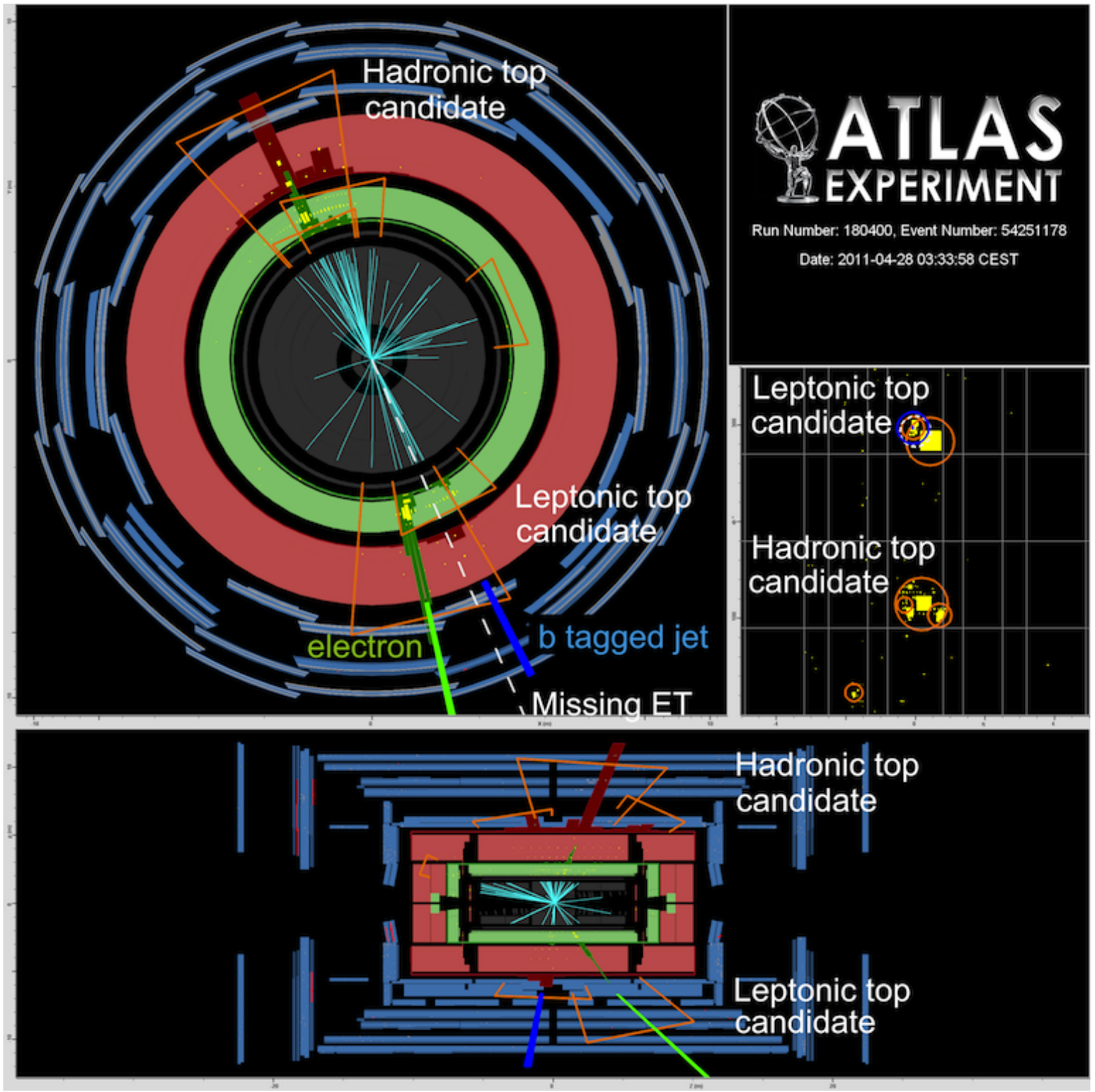
Randall-Sundrum Modell:

- arXiv:hep-ph/0701166; ATL-PHYS-PUB-2010-008
- Exclude low masses (< 700 GeV)

heavy resonances: boosted top pairs

ATLAS-CONF-2011-087

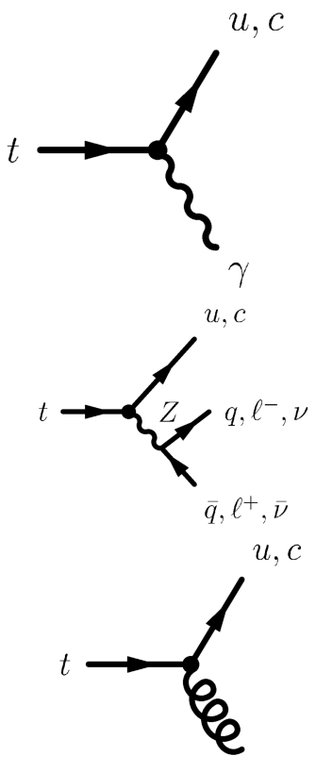
- candidate event with m_{tt} ~ 1.6 TeV
- tops get heavily boosted → will get merged into one jet at higher masses
- need other reconstruction strategy
- idea: use fat jets that contain all partons
- use jet mass as discriminant
- need to handle pile-up
- first studies show good mass resolution in simulation and also good data-MC agreement

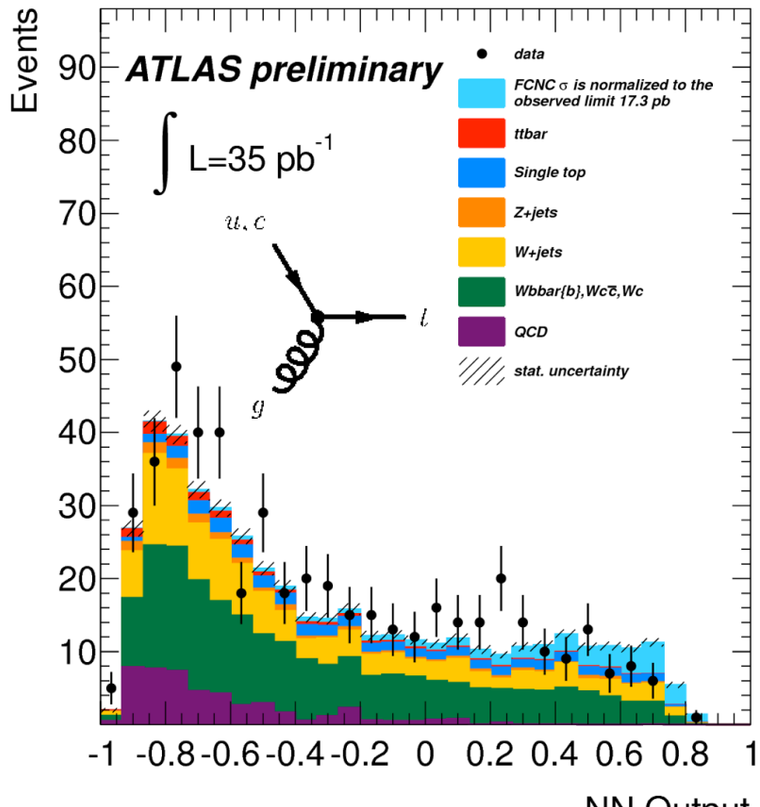


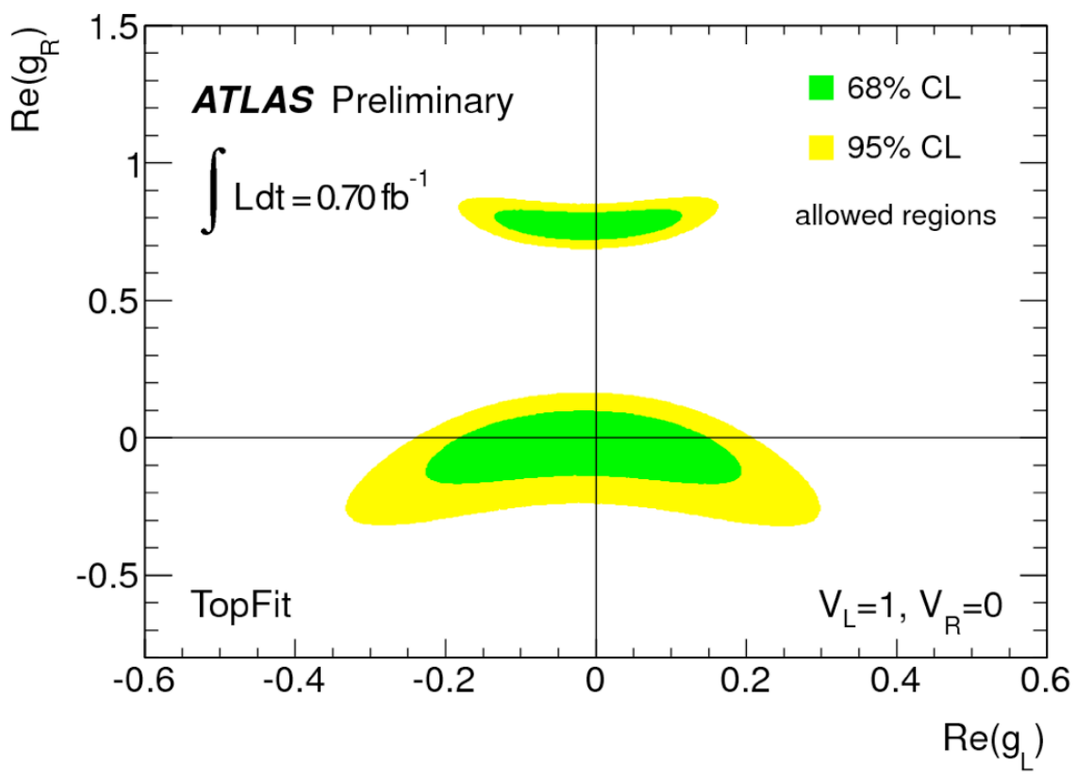
FCNC and anomalous couplings

ATLAS-CONF-2011-061
ATLAS-CONF-2011-122

- search for flavour changing neutral currents in top decay and production
- set limits on t→qZ branching ratio
- upper limits on qg→t→blv production



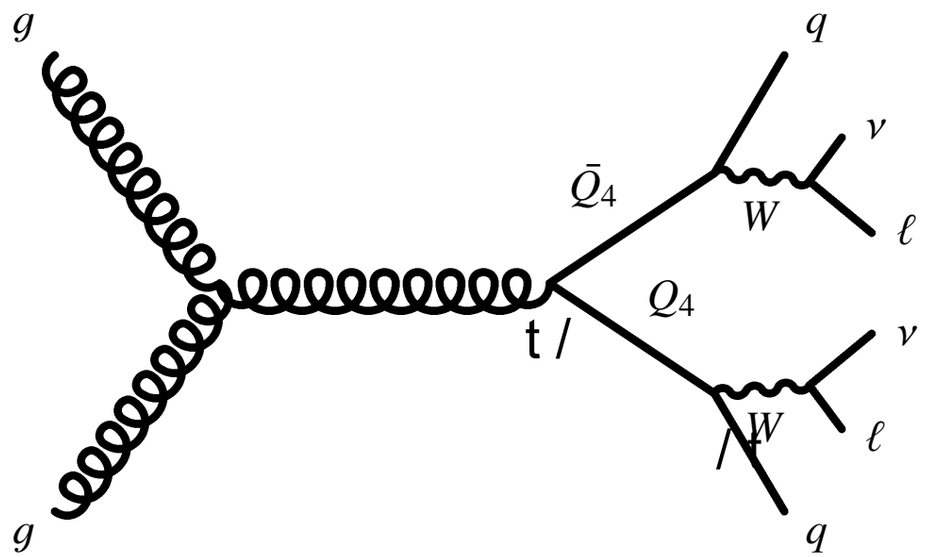




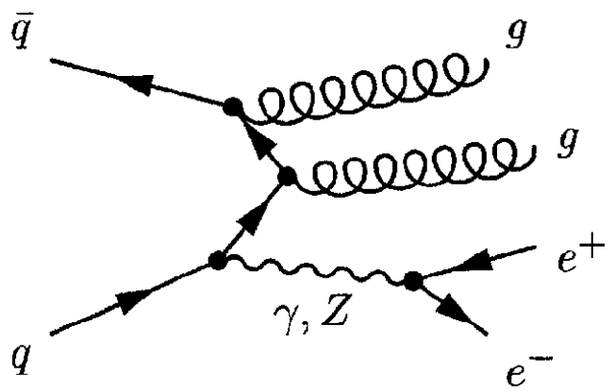
- measurement of the polarisation of the W bosons in top quark decays
- sensitive to structure of Wtb vertex
- set constraints on anomalous couplings

dileptonic signature

two leptons in final state



major backgrounds:
Z/γ+jets background (normalisation from data)
diboson production



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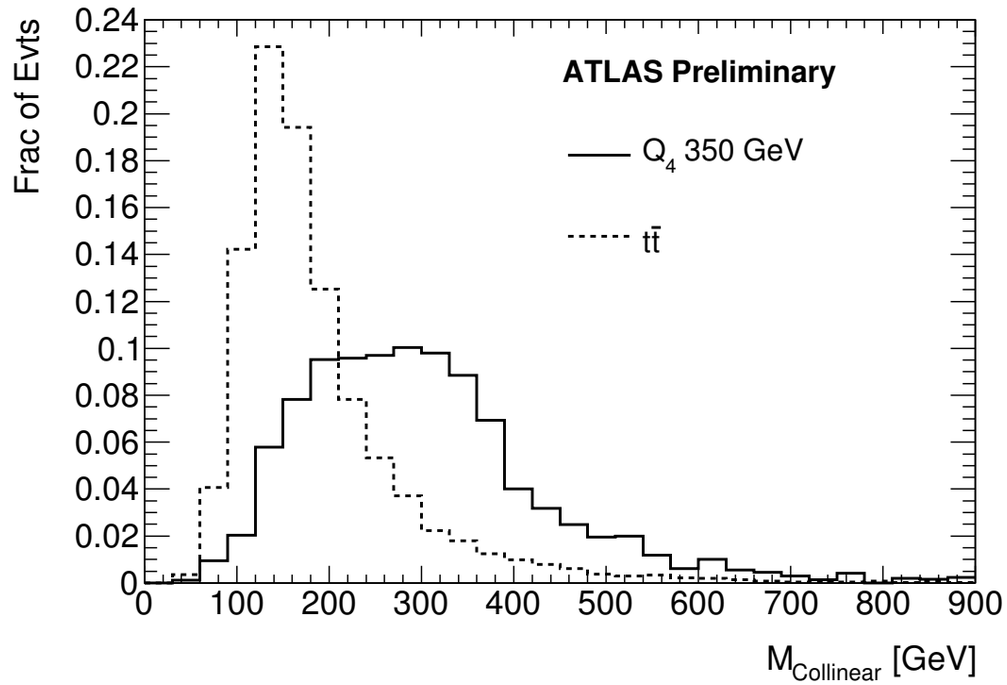
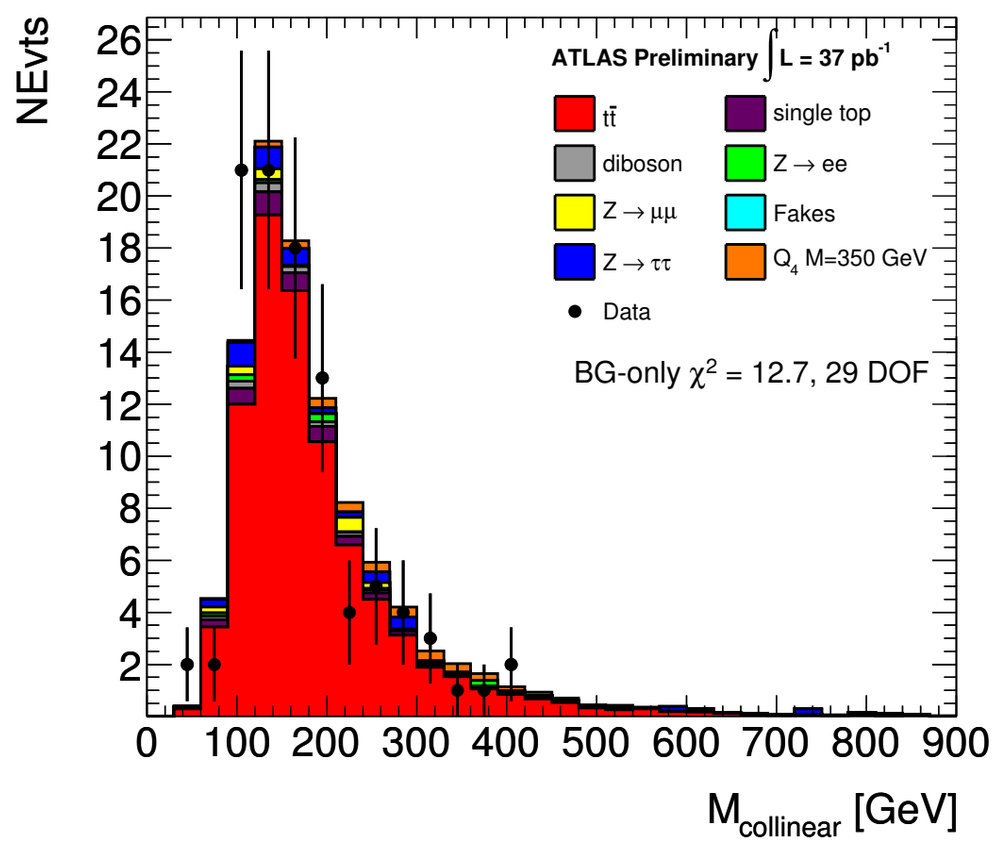
fourth generation quarks

ATLAS-CONF-2011-022

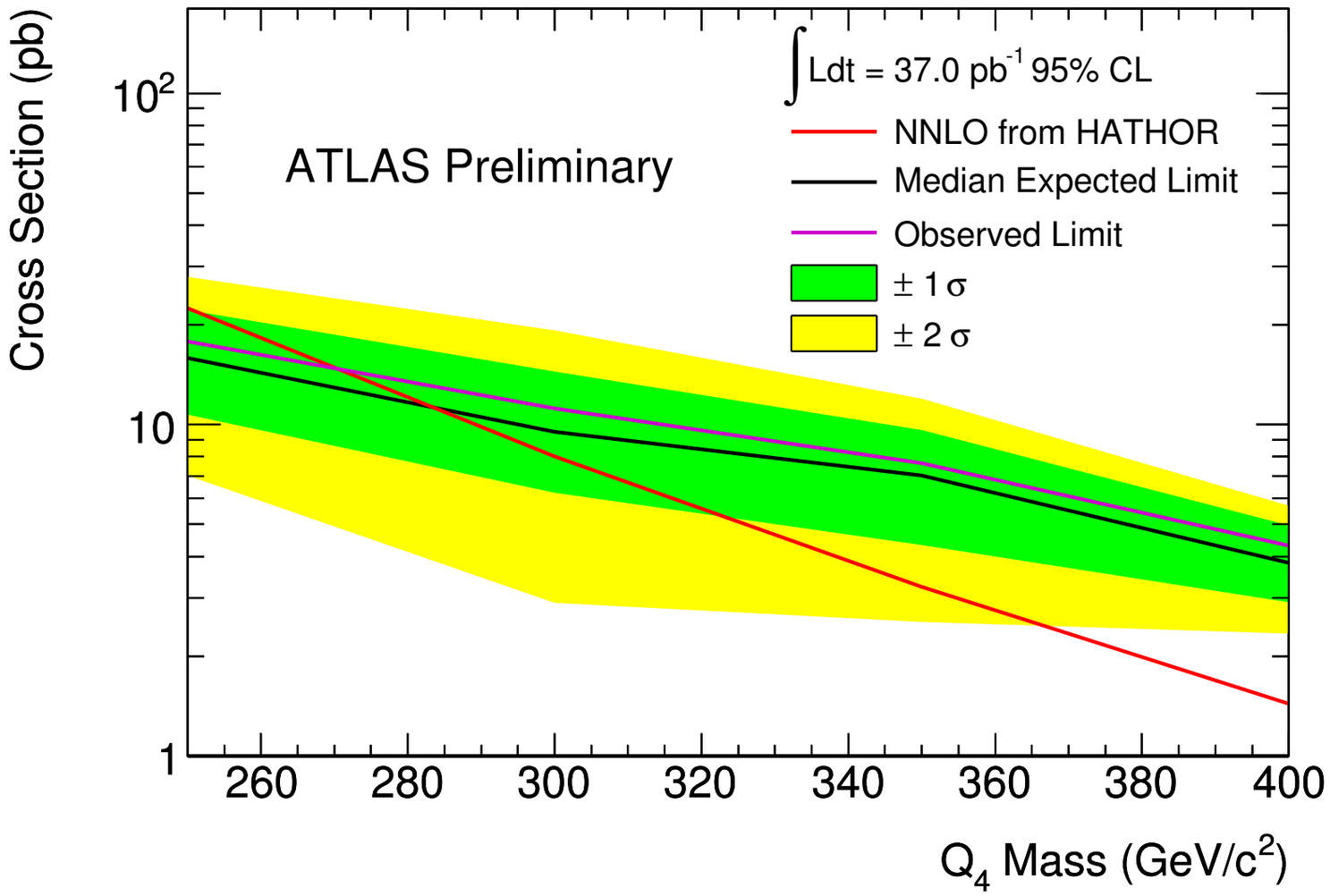
- natural extension of Standard Model
  - add CP violation for baryon asymmetry
  - Higgs naturalness problem
- top-like Q_4 decaying into Wq
  - arXiv:0907.3155, σ(m≈300 GeV)~ 5pb
  - independent of Q_4 charge (can test 4/3 to -1/3e)
- higher boost than top decays
- discriminant: collinear mass (neutrino has same flight direction as lepton)
- challenging: look for a broad excess





fourth generation quarks: limits

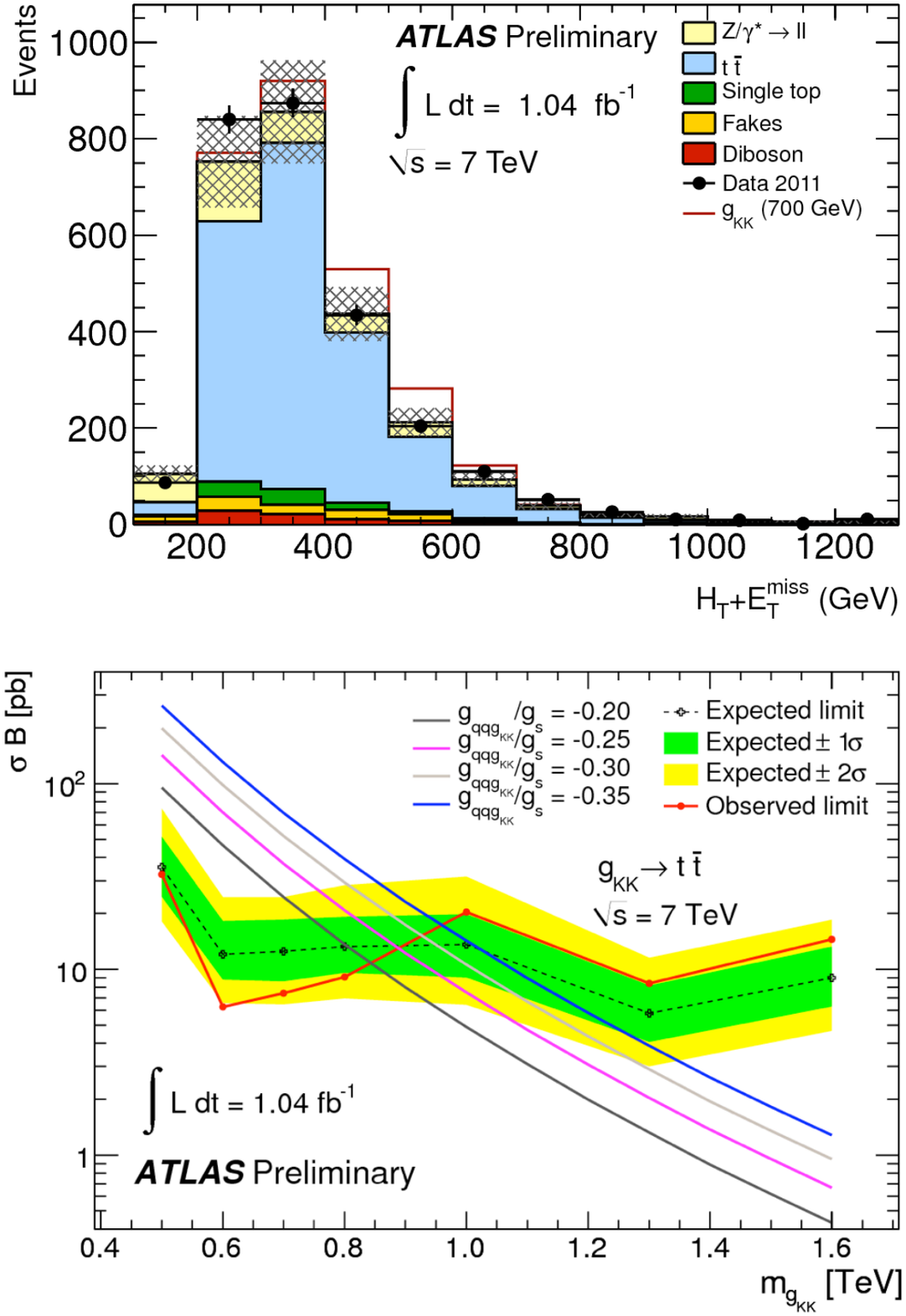
- set limit for production cross-section of Q_4
- translates into lower mass limit: $m_{Q4} > 270$ GeV
  - Best Tevatron limits: CDF, 4.6 fb^{-1}: $m_{Q4} > 335$ GeV



dilepton resonances

ATLAS-CONF-2011-123

- first result obtained in dilepton channel
- complementary to single leptonic result
- use H_T + MET distribution
- uses large dataset
- set limits on the cross-section × branching ratio for Kaluza Klein gluons
- m_{KK} > 0.84 TeV (95% C.L.) in Randall-Sundrum model
- comparable to single-leptonic result (but significantly more statistics)



summary

- LHC provides ideal environment for new physics in top-like states
  - larger production cross-sections for heavy particles
  - high statistics available
- several new physics signals already studied
  - heavy particles decaying into top pairs + MET
  - resonances decaying into top pairs (both single leptonic and dileptonic channel)
  - flavour changing neutral currents and anomalous couplings
  - limits on fourth generation quarks
- analyses are constantly updated with higher statistics
- boosted tops very promising for future analyses